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Full Scale Dynamic Tests on One-Way Spike Barriers

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16. ABSTRACT
Freeway accident statistics show that eight percent of the fatal accidents that occur on freeways are caused by wrong-way movements. Forty percent of these wrong-way fatalities are caused by vehicles entering freeways at off-ramps.

It is felt that engineering ingenuity should be able to devise an effective method of preventing these wrong-way vehicles from entering the freeway. An electronic sensing unit activated only by wrong-way vehicles that incorporates signing, a red light, and a horn has been installed on a freeway off-ramp test installation south of Sacramento. Studies testing the effectiveness of various signs have been conducted. The use of pavement delineation such as arrows and lane marking has been tried and the use of colored pavement contemplated.

One device that has often been proposed for prevention of wrong-way vehicle movements is the spike barrier installation commonly used for traffic control in parking lots. This spike barrier consists of 0.331 inch diameter steel coil springs mounted on steel pipes and set in the pavement so that one end of the spring protrudes approximately six inches at a 45 degree angle opposing wrong-way vehicles. The protruding spikes are approximately three and one-half inches apart. The spring action of the coils pivoting on the steel pipes allows the spikes to be depressed by right-way vehicles, but the mounting method and angle prevents this when they are contacted by a wrong-way vehicle.

The object of this study was to determine the effectiveness of these spike barriers in quickly but safely disabling a wrong-way vehicle, thus preventing it from continuing onto the freeway. This test program was initiated by a letter from J.E. Wilson, Traffic Engineer, to J. L. Beaton, Materials and Research Engineer, dated August 6, 1964.

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STATE OF CALIFORNIA
HIGHWAY TRANSPORTATION AGENCY
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

FULL SCALE DYNAMIC TESTS ON ONE-WAY SPIKE BARRIERS

JANUARY 1965

State of California
Highway Transportation Agency
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Division of Highways
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Proj. W. O. 64354-R
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Mr. J. E. Wilson
Traffic Engineer
Traffic Department
Calif. Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is a report of:

FULL SCALE DYNAMIC TESTS

ON ONE-WAY SPIKE BARRIERS

Study made by . . . . Structural Materials Section
Under general direction of . . . . E. F. Nordlin
Work supervised by . . . . R. N. Field
Project Engineer . . . . C. R. Ledbetter
Report prepared by . . . . R. N. Doty and C. R. Ledbetter

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

RNF/RND/CRL:mw

I. INTRODUCTION

Freeway accident statistics show that eight percent of the fatal accidents that occur on freeways are caused by wrong-way movements. Forty percent of these wrong-way fatalities are caused by vehicles entering freeways at off-ramps.

It is felt that engineering ingenuity should be able to devise an effective method of preventing these wrong-way vehicles from entering the freeway. An electronic sensing unit activated only by wrong-way vehicles that incorporates signing, a red light, and a horn has been installed on a freeway off-ramp test installation south of Sacramento. Studies testing the effectiveness of various signs have been conducted. The use of pavement delineation such as arrows and lane marking has been tried and the use of colored pavement contemplated.

One device that has often been proposed for prevention of wrong-way vehicle movements is the spike barrier installation commonly used for traffic control in parking lots. This spike barrier consists of 0.331 inch diameter steel coil springs mounted on steel pipes and set in the pavement so that one end of the spring protrudes approximately six inches at a 45 degree angle opposing wrong-way vehicles. The protruding spikes are approximately three and one-half inches apart. The spring action of the coils pivoting on the steel pipes allows the spikes to be depressed by right-way vehicles, but the mounting method and angle prevents this when they are contacted by a wrong-way vehicle.

The object of this study was to determine the effectiveness of these spike barriers in quickly but safely disabling a wrong-way vehicle, thus preventing it from continuing onto the freeway. This test program was initiated by a letter from J. E. Wilson, Traffic Engineer, to J. L. Beaton, Materials and Research Engineer, dated August 6, 1964.

II. SUMMARY AND RECOMMENDATIONS

The standard spike barrier (Exhibit 1) will not effectively disable an automobile traveling against the spikes at speeds of from 15 to 60 mph for the following reasons: (1) spike penetration will puncture a tire but does not cause a blowout. The elapsed time from puncture to disablement or recognition by the driver that the tire is flat varies from 10 seconds to over 5 minutes. Due to the self-sealing properties of the tubeless tires used on modern vehicles, the puncture inflicted by this barrier frequently would not be severe enough to disable a vehicle in time to prevent its continued travel onto a freeway. (2) The spikes are not close enough together to prevent narrow tires (5:60 and smaller) such as are used on compacts and small foreign cars from passing between them (Exhibit 2).

By modifying the spikes with the addition of a barb (Exhibits 3 and 4) near the end of the spike, an automobile can be more quickly disabled, providing the tire contacts the spike squarely. This modification will enable the spike to rip a hole large enough to deflate a tire within 10 to 30 seconds from contact. However, as noted with the standard spike barrier, the narrow tires used on compacts and small foreign cars were also able to pass between the modified standard spike barrier. The spacing between the spikes would have to be reduced by at least one third to correct this deficiency.

The attachment of barbs would necessitate a further modification in the mounting assembly to enable the barbed spike to lie flat when depressed by right-way traffic. Furthermore, the addition of barbs to create a disabling puncture increases the hazards of a spike being bent back as in Test 15 (Exhibit 7), creating a barrier for the right-way driver.

Analysis of the test data film (Exhibit 5) shows that in some cases the blunt ended spike (Exhibit 4) and the rigidity of the spring enabled the tires to roll over the spikes with no disabling puncture taking place. To prevent this, the spikes should be pointed at the ends as well as barbed to insure complete penetration and deflation.

The test drivers indicated that it was impossible to determine the direction of the spikes when approaching this barrier (Exhibit 6). Therefore, there could be a lack of assurance to the right-way driver that he could or could not safely continue over a barrier of this type.

The ability of this spike barrier installation to withstand long term repetitive impact from heavy traffic was not tested; however, the manufacturer did not recommend that his production model be installed in a heavily traveled roadway.

Although in these tests there was no loss of control or tendency for the test vehicles to roll, it cannot be assumed that this barrier would not create hazardous conditions for either an inexperienced driver, a vehicle with worn or tube type tires, or a vehicle traveling at high speeds. It should be anticipated that passage of vehicles either in the right way or the wrong way over the spike barrier could cause dangerous out-of-control situations, particularly where speeds in excess of 40 mph will occur.

III. TEST PROCEDURE

This test series was conducted in two parts (Exhibit 8). The first part, Runs 1 through 11, consisted of driving two types of vehicles with and against a standard spike barrier at speeds of 15, 30, and 60 mph. The vehicles used in the tests were a 1961 Dodge and a 1960 Volkswagen. The tires were new 5.60 x 15, 4 ply tubeless on the Volkswagen, and 7.60 x 15, 6 ply and 2 ply tubeless on the Dodge. The 6 ply, 7.60 x 15 tires were used, in good condition, and the 2 ply tires were new.

Documentary and data film coverage for these tests was obtained with two Photosonic high speed cameras, one Hulcher sequence camera, and one Bolex documentary camera. The Bolex was used for a documentary motion picture pan of the tests, the Hulcher for a series of documentary sequence pictures through contact with the spikes, and the Photosonics for a high-speed data record of tire contact with the spikes.

The time taken for the tires to become flat was recorded, and all tires on the vehicle examined for damage. Tests were made with both two and four tires making contact with the spikes.

The second part, Runs 12 through 16, incorporated the same procedures with the following exceptions:

(1) Only 2 and 4 ply tires were used.

(2) Tests were conducted with only two tires contacting the spike barrier installation.

(3) Wedge shaped barbs (Exhibits 3 and 4) were welded to the underside of the spikes for the purpose of inflicting a gouging puncture that would quickly deflate the tire.

(4) The maximum speed was reduced from 60 mph to 40 mph. This was decided after studying the results of the first tests (Exhibit 8) which showed that a disabling puncture was less likely to occur at the lower speeds than at the high speeds.

IV. DISCUSSION

The choice of vehicles for this study was complicated by the large number of different types and weights of vehicles on the road today, and also the wide variation in tire sizes used on these vehicles. The 1961 Dodge was considered to be representative of the majority of the medium weight vehicles being driven at the present time. The Volkswagen sedan, with its narrow tire, was selected as representative, in weight, of the foreign car, sports car, and compact car segment of vehicles on our roadways. Also, in the event of a blowout, the Volkswagen was considered the most unstable of this type vehicle.

Tubeless tires, rather than tube type, were selected for this test series because it was felt that they would be more representative, and due to their self-sealing characteristics, would offer the most resistance to blowout when punctured. It can be assumed that if the barrier is effective in disabling a vehicle with tubeless tires, it would also be effective in disabling a vehicle with tube-type tires, which are more readily blown out.

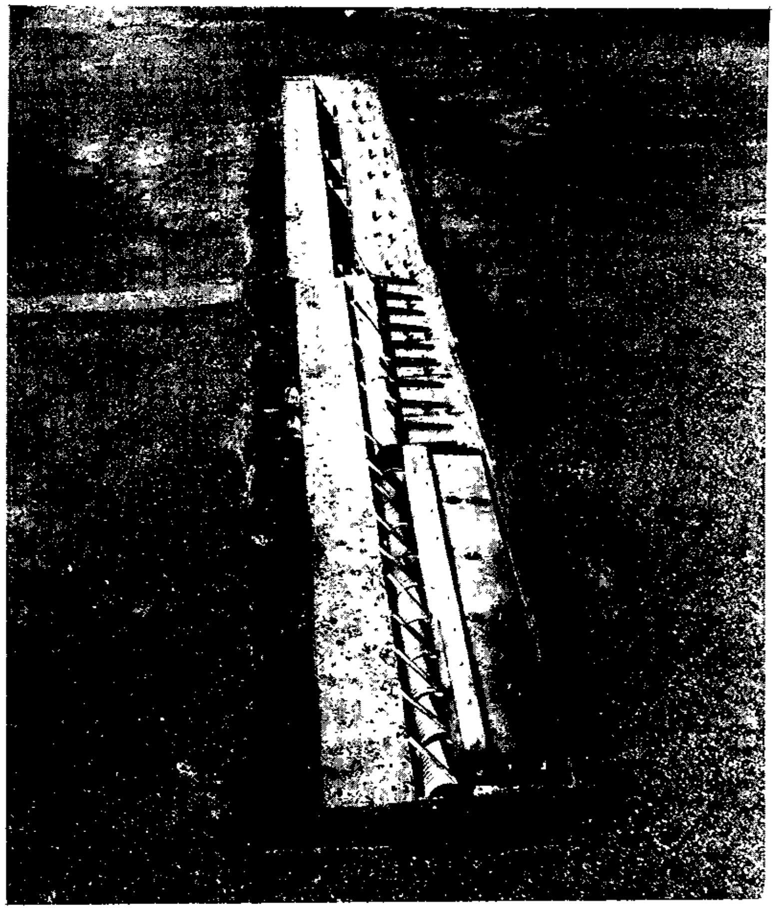
The test drivers indicated that they noticed no vehicle reaction in the cases where the tires were punctured and that there was no tendency for the vehicle to pull one way or the other. However, it cannot be assumed that tube-type tires would perform similarly. As the tube-type tire has no self-sealing properties, it is possible that a penetration by the barbed spike in a tube tire would have resulted in a blowout, with subsequent violent reactions.

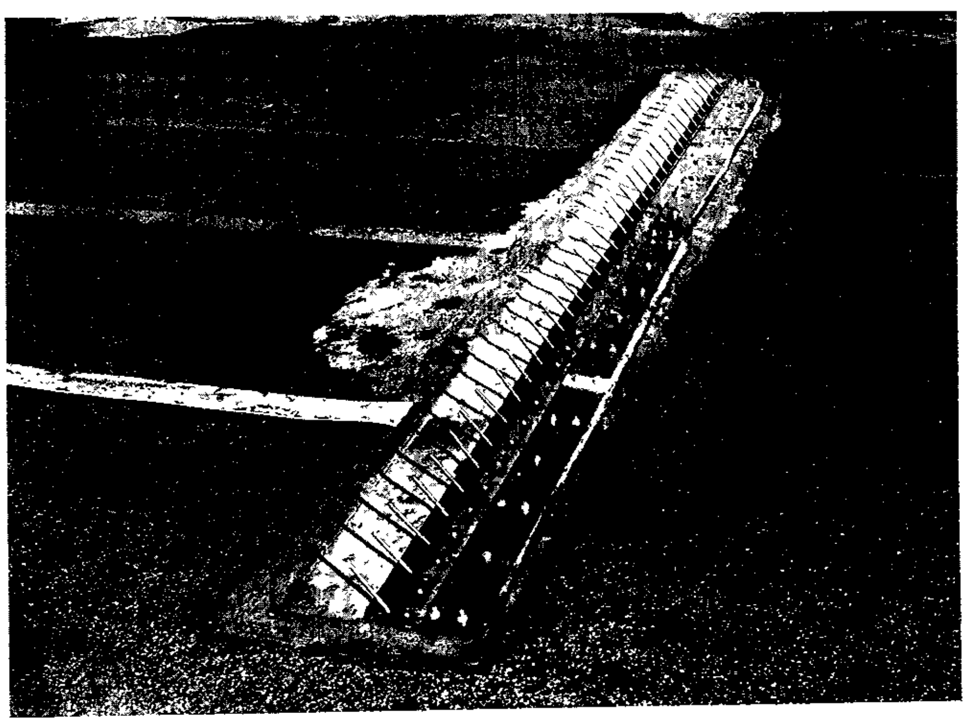
The runs conducted in Part I of these tests proved that the standard spike barrier as manufactured is not effective in disabling either a large or small vehicle in sufficient time to prevent their wrong-way entry onto the traveled portion of a freeway. In no case was the Volkswagen disabled, and in two out of three tests with the Dodge the puncture was not severe enough to cause rapid disablement (Exhibit 8).

After installation of a wedge shaped barb near the tip of the spike, the effectiveness of the barrier in disabling both the Dodge and the Volkswagen was greatly increased. In Run No. 15, the ripping effect of this barbed spike caused the right front tire of the Volkswagen to become completely flat within 15 seconds after impact. In both tests with the Dodge on the barbed spike, all tires contacting the barrier were punctured and flat within 25 seconds after impact. In these three tests the driver reported that it was evident to him within a few seconds after contact with the barrier that the tires were going flat. However, t should be noted in Exhibit 8 that in two of the three Volkswagen tests, in Part II, Runs 13 and 14, the car was not disabled, and that in Run No. 15 one spike (Exhibit 7) was bent back by the barb catching as it pulled out of the punctured tire. Spikes bent back in this manner in in-service installations would create an extremely hazardous and unacceptable condition for right-way traffic.

The high speed data pictures from Run No. 13 (Exhibit 5) clearly illustrate that the weight of the Volkswagen was not great enough to enable the blunt ended spike to fully puncture the tire. The end of the spike would have to be pointed to guarantee a disabling puncture. The Dodge (Run No. 16) also rode up on the spike slightly (Exhibit 5), but the weight of this vehicle was sufficient to force the tip of the spike into the tire.

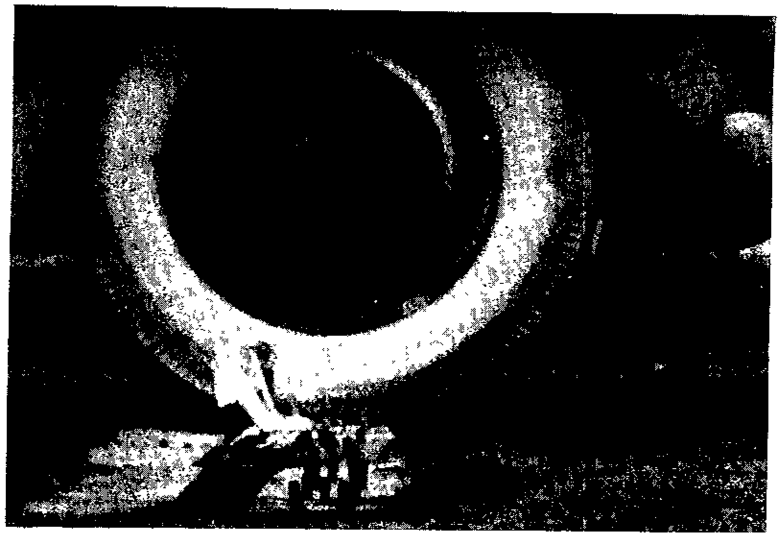
One of the most critical characteristics of any device installed in an off-ramp to prevent wrong-way travel is the effect it has on the traffic traveling in the correct direction. It is extremely undesirable to install any device that would appear hazardous to the right-way driver and cause him to either stop on a ramp or swerve to avoid the device. All drivers at the test site found that it was impossible to determine the direction of the spikes when approaching the barrier from either direction (Exhibit 6).





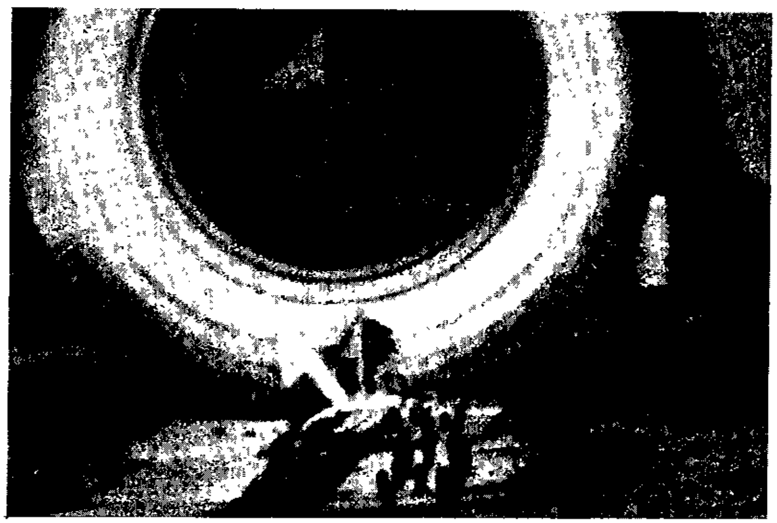
STANDARD SPIKE BARRIER INSTALLATION -- RUNS 1 THROUGH 11.

EXHIBIT 2



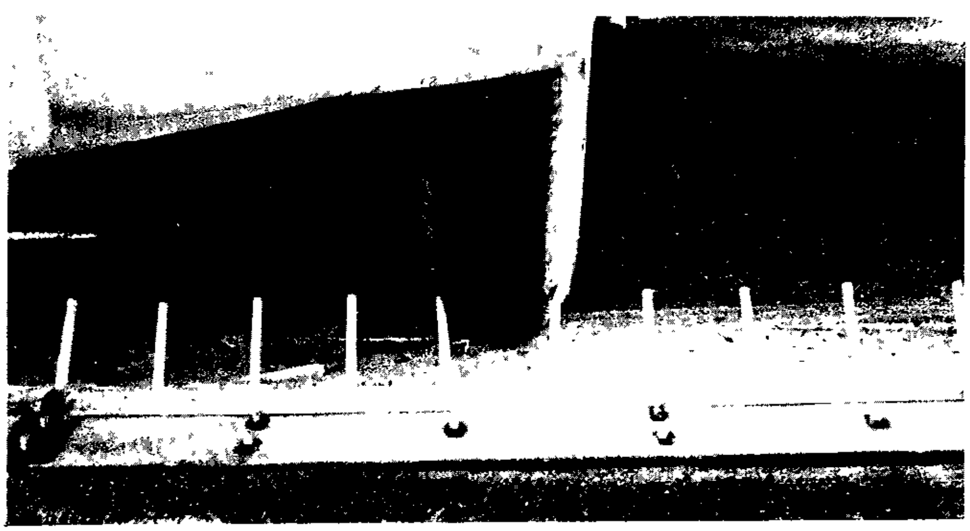
Side View

Front Tire



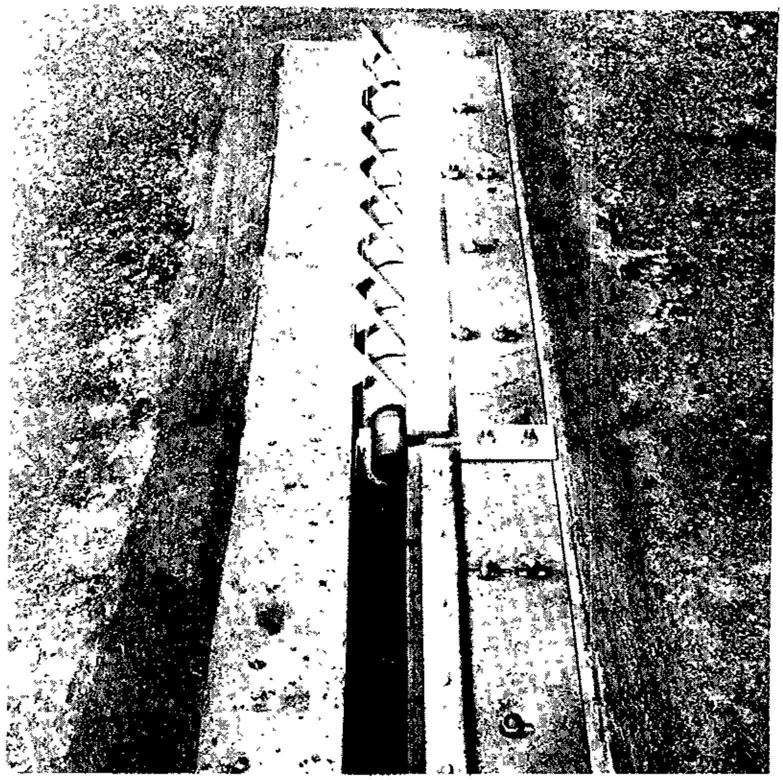
Side View·

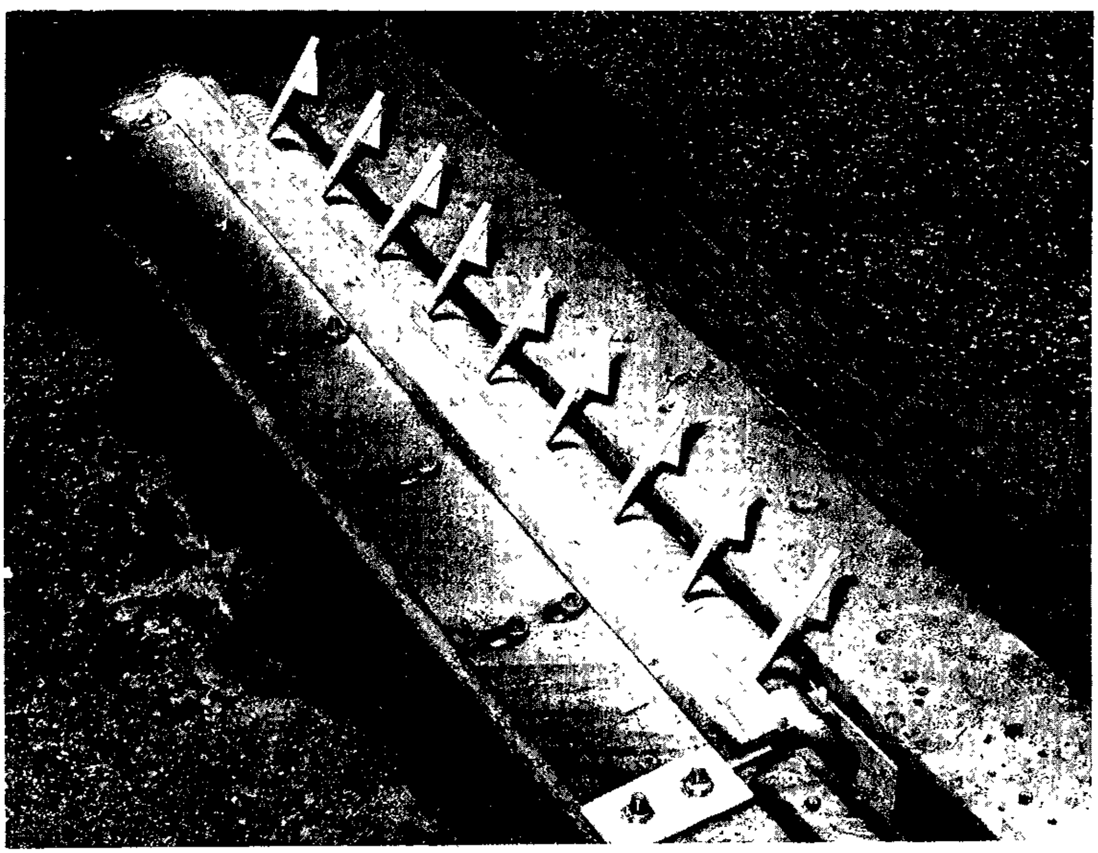
Rear Tire



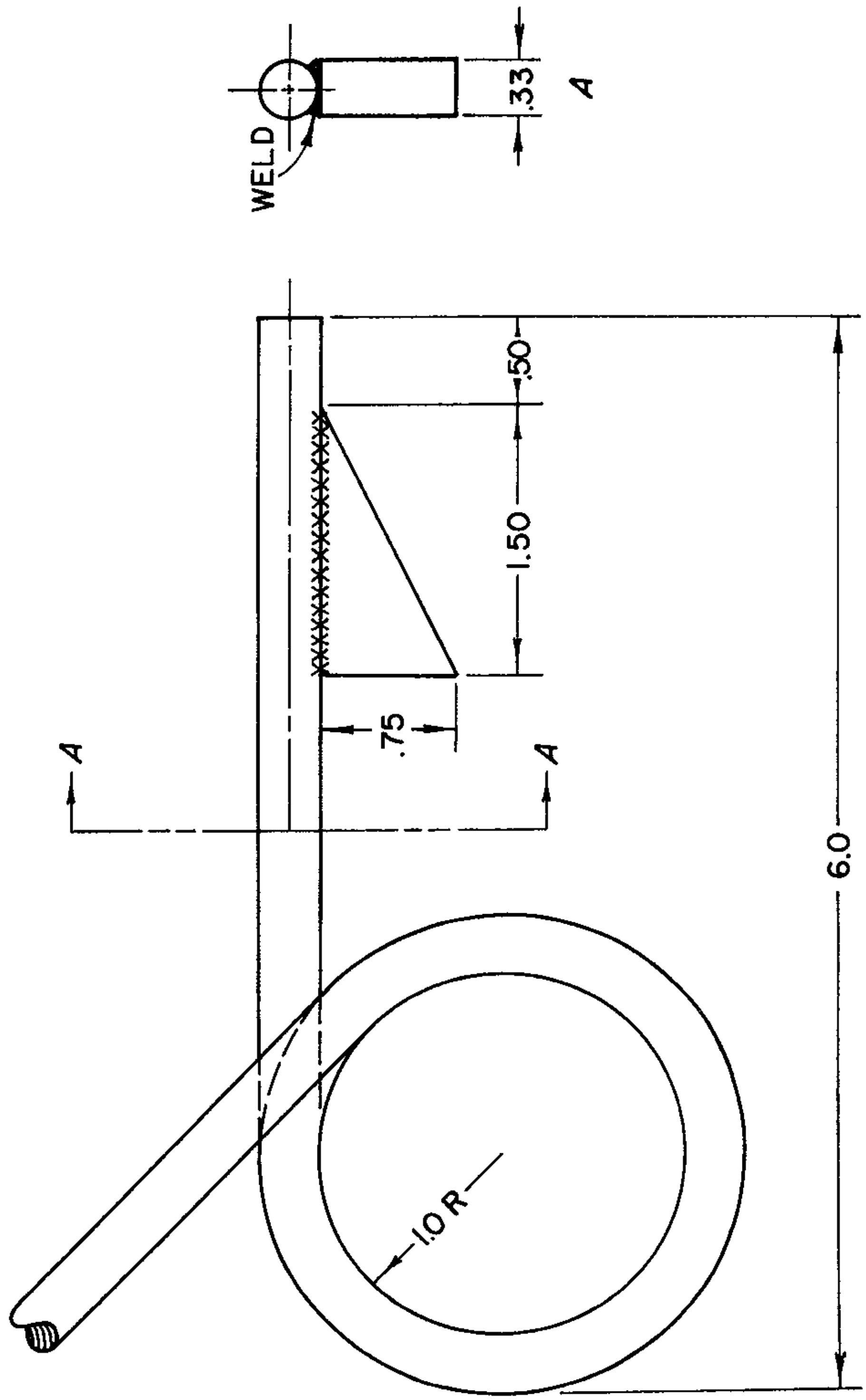
Front View

COMPARISON OF VOLKSWAGEN TIRE WIDTH WITH SPIKE SPACING.

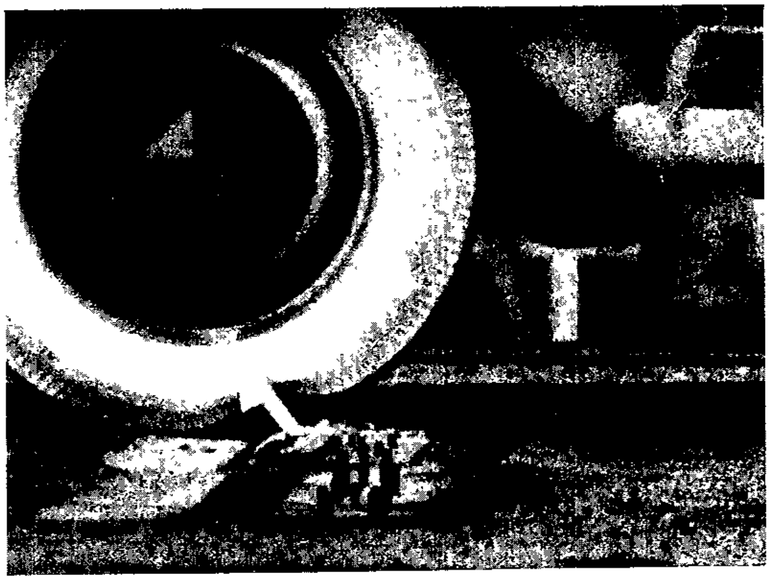




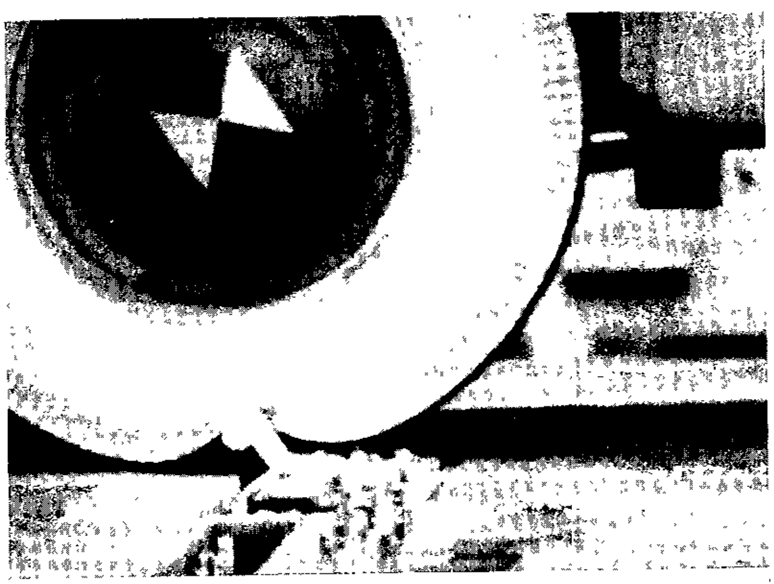
MODIFIED SPIKE BARRIER INSTALLATION -- RUNS 12 THROUGH 16.



SPIKE MODIFICATION FOR PART II

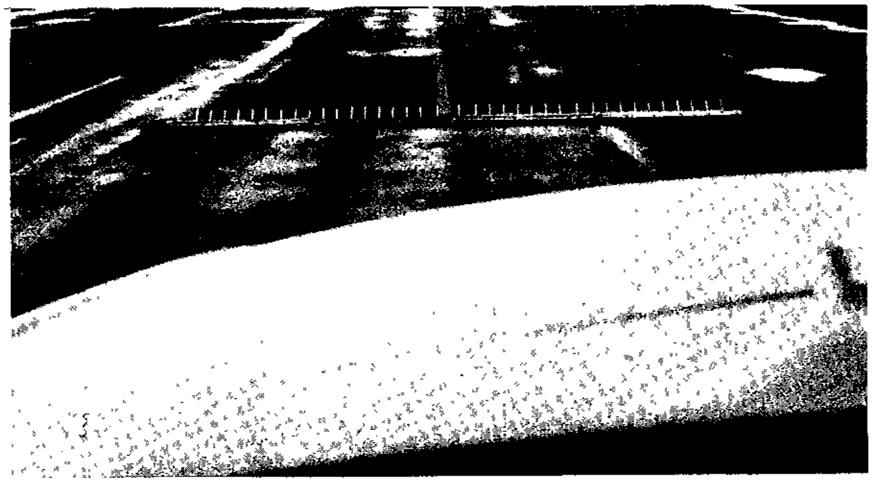


Volkswagen
Vehicle Not Disabled
(Run No. 13)



Dodge
Vehicle Disabled
(Run No. 16)

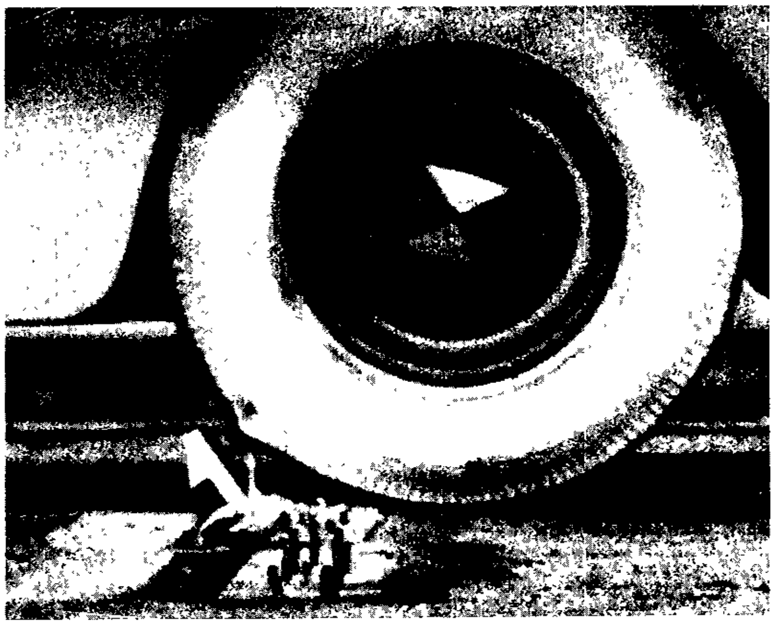
TIRE DEPRESSION CAUSED BY BLUNT ENDED SPIKES.



Right Way Appearance.

Wrong Way Appearance.

APPEARANCE OF SPIKE BARRIER FROM VEHICLE.



MODIFIED SPIKE TEARING OUT PORTION OF TIRE.

PERMANENT SET-IN SPIKE.

RUN NO. 15

SPIKE BARRIER TEST SEQUENCE

RUN NO.	VEHICLE	DIRECTION (WITH OR AGAINST SPIKE)	SPEED (MPH)	NO. OF TIRES CONTACTING BARRIER	TIRE PLY	TIME TO DISABLE VEHICLE	TIRES PUNCTURED
1	61 DODGE	WITH	30	4	6	–	–
2	61 DODGE	"	60	4	6	–	–
3	60 VOLKS.	"	30	4	4	–	–
4	60 VOLKS.	"	60	4	4	–	–
5	61 DODGE	AGAINST	30	4	6	OVER 5 MINS.	LR, RF, RR.
6	60 VOLKS.	"	30	2	4	" " "	NONE
7	61 DODGE	"	60	4	2	10 SECONDS	ALL
8	60 VOLKS.	"	30	4	4	OVER 5 MINS.	RF
9	60 VOLKS.	"	60	4	4	" " "	LF, LR, RF.
10	61 DODGE	AGAINST 25°	15	4	2	" " "	ALL
11	60 VOLKS.	" "	15	4	4	" " "	RF
12	61 DODGE	AGAINST	40	2	2	10 SECONDS	RF, RR
13	60 VOLKS.	"	20	2	4	OVER 3 MINS.	RF
14	60 VOLKS.	"	40	2	4	NOT DISABLED	NONE
15	60 VOLKS.	"	40	2	4	15 SECONDS	RF
16	61 DODGE	"	20	2	2	25 SECONDS	RF, RR

NOTES:

(1) RUNS 1 THRU 11 WERE ON STANDARD SPIKE BARRIER.

(2) RUNS 12 THRU 16 WERE ON SPIKE BARRIER WITH BARB WEDGES ADDED.